Isotropic Broadband Field Strength Meter

Model HI 3001

S/N ~~39356~~ 39202

Features/Specifications

(1) Full-time automatic zero! Even while performing measurements. THIS DOESN'T SOUND SO GOOD!

(2) Peak hold memory circuit.

(3) LED indicators for overload and battery status.

(4) Audio output, ticking sound is proportional to meter reading.

(5) Recorder output, 0 to 1 volt corresponding to meter reading.

(6) Instrumentation readout is in field strength units squared.

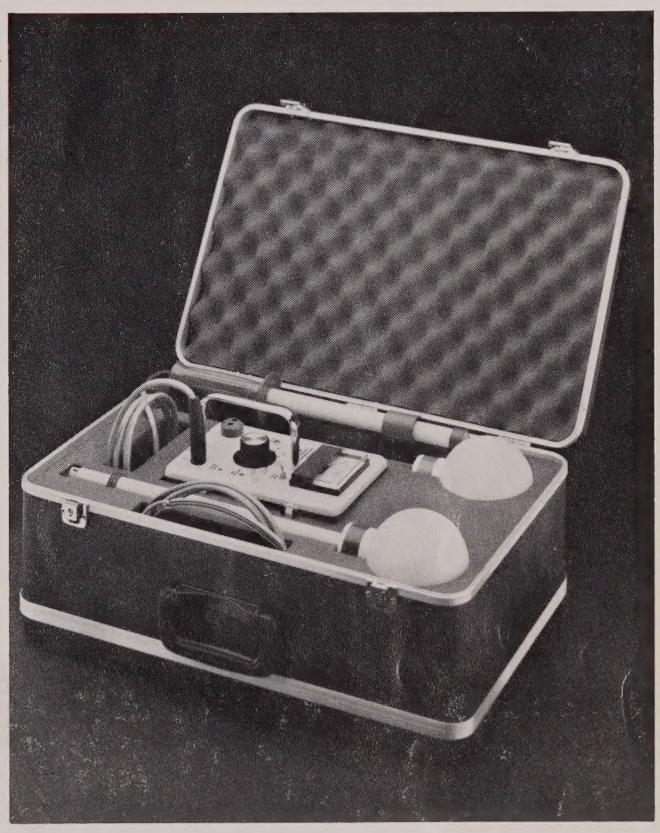
(7) Operates on 14 C size batteries.

(8) Size (instrumentation package): 8⅛" x 5⅛" x 4⅞".

(9) Weight: 6.5 lbs.

(10) Total length of probe and handle with probe inserted: 30 inches.

(11) Overload: Can withstand CW signal to 800% of full scale of maximum probe range.



	Green Probe	Red Probe
Range 1	10^2 V²/M² Full Scale	10^5 V²/M² Full Scale
Range 2	10^3 V²/M² Full Scale	10^6 V²/M² Full Scale
Range 3	10^4 V²/M² Full Scale	10^7 V²/M² Full Scale

Frequency Response:
0.5 MHz to 6 GHz : ±2 dB
1 MHz to 1 GHz : ±1 dB
3 MHz to 500 MHz : ±.5 dB

Isotropicity: ±.5 dB for both Green and Red probes.

Calibration accuracy at calibration frequencies: ±.5 dB for both probes.

The HI-3001 comes complete with two E-field probes, batteries, headset and instruction manual in an attractive carrying-case.
Available options include H-field probe, high sensitivity E-field probe and rechargeable ni-cad battery pack with charger.

U.S. Patent #4,365,192

2-15-84

For Additional Information Call or Write:
HOLADAY INDUSTRIES, INC.
General Offices:
14825 Martin Drive
Eden Prairie, MN 55344
Telephone: (612) 934-4920
Telex: 29-0922

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HOLADAY INDUSTRIES, INC.

BROADBAND ISOTROPIC FIELD STRENGTH METER

OWNER'S MANUAL

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Section 1

SYSTEM OVERVIEW

The Holaday HI-3001 Isotropic Broadband Field Strength Meter has been designed primarily for field use to measure both electric and magnetic fields.

The design of the E-field probe is based on the diode-dipole antenna developed by Bowman of NBS, Boulder Colorado. The use of three mutually orthogonal dipoles provides isotropic response. That is, the total field strength at the probe is displayed, regardless of the field orientation or probe receiving angle. The probes are extremely durable and will withstand overloads of 800% of full scale.

what about H-field probe?

The instrumentation package contains the battery pack, electronic circuit boards, analog meter and other front panel features. These include 1) peak hold memory switch, 2) range selector switch, 3) battery status light, 4) over range light, 5) audio output, and 6) recorder output. There is no zero adjust knob, since the instrument has full-time automatic zeroing. There is no need to place the probe in a zero field condition in order to zero the meter.

Section 2

OPERATING INSTRUCTIONS

2.1 INTRODUCTION

This section contains instructions for the use of the instrument, including an explanation of all the features of the instrument; and information on converting units of measure.

2.2 UNPACKING AND INSPECTION

The HI-3001 is shipped in a handsome, protective carrying case. The foam insert is designed to provide storage for each component of the system. The white foam block on the instrument handle should be saved and used each time the instrument is transported in the carrying case. Each HI-3001 system contains the following:

1 HI-3001 instrumentation package with battery pack (14 C cells, alkaline)
1 High field probe (red)
1 Low field probe (green)
1 Acoustic headset
1 Probe handle/cable

2.3 OPERATING INSTRUCTIONS

A. Select the probe for the appropriate range of expected readings. Insert the probe into the handle and, with light pressure, rotate the probe until the keyway is felt and alignment marks meet, then fully seat probe in handle connector. Secure the probe in the handle by tightening the locking collar.

B. Turn the selector switch to the desired range. The probes are color coded with a green or red band, and correspond to the green or red scale multipliers as selected by the selector switch on the front panel.

When using the green probe on the lowest range, an indication may occur when no field is present, due to flexing of the cable.

C. The "Battery" indicator LED will blink when the unit is turned on and the batteries are good. When the battery voltage drops below a safe operating level, the LED will come on steady and will not blink. The battery pack consists of 14 C cells and will provide approximately 30 hours of continuous use to 40 hours of intermittant use.

D. Depress the peak hold switch to clear the memory. There is no zero adjust since the unit has automatic, full-time self-zeroing capability.

E. The memory is active at any time the instrument is on, continually being updated with the highest reading observed. The memory reading can be called for at any time by depressing the peak hold switch. The reading obtained will be the highest reading observed since the last time the switch was depressed, since releasing the switch automatically clears and zeros the memory. The time constant of the memory circuit is much faster than the circuits driving the analog meter and the recorder output, which enables the memory to capture a higher peak reading on a fast rise-time pulse. Therefore, the memory reading may appear higher than the meter needle indication. Since a time-averaged signal is important in making safety measurements, the actual meter indication or recorder output will provide a more suitable reading.

F. The "Over Range" LED will light should any of the following conditions occur: a) the integrated signal is greater than full scale, b) the peak of any amplitude modulation is greater than the top of the diode shaping ROM, c) any common mode signal is present which is large enough to cause the front end amplifier to malfunction. An audible alarm will also be heard through the headset when any of these conditions occur. In the event of any over range condition simply switch to the next higher range. The meter, of course, will automatically rezero itself.

G. On the lower left of the front panel there is a port for driving the acoustical headset provided. The repetition rate of the ticking sound is proportional to the meter reading and allows the operator to listen for the high field region while observing probe placement.

H. On the left side of the front panel there is a recorder output jack. The signal available at this port is calibrated to one volt for full scale indication. The source impedance is 5K ohms.

I. The "Aux A" and "Aux B" switch position is for use with either the optional H-field probe or the optional high sensitivity E-field probe.

J. Although it is recommended that the unit be turned off to change probes, no damage will occur if the unit is on while changing probes. While handling probes it is important to eliminate the possibility of static discharge to the probe connector while it is not plugged in.

2.4 UNITS OF MEASURE

The analog meter on the HI-3001 displays $|FSU|^2$, which means field strength units squared. When using an E-field probe the units are V^2/M^2 and when using an H-field probe the units are A^2/M^2. The meter on the HI-3001A displays V/M.

In the far-field region (distances greater than several wavelengths from an RF source) the E and H fields are in phase and vary gradually with distance creating a uniform plane wave condition. The ratio of E/H is constant and has the value of 377 ohms, termed the impedance of free space.

In the near-field region both the E and H field strengths vary greatly with small changes in distance from the source, and the ratio of E/H is not constant.

Therefore, the standards have been written specifying the measurement of both E and H fields. Each must be measured independently, regardless of the units of measure displayed on the meter.

In the far field the power density can be calculated from either the E or the H field by using 377 ohms (Ω), the impedance of free space, as follows:

$E^2 \div \Omega$ = power density (in W/M^2)

$H^2 \times \Omega$ = power density (in W/M^2).

The power density in W/M^2 must then be multiplied by a conversion factor of 0.1 to yield mw/cm^2.

Using the conversion factor of 0.1 these equations become:

$E^2 \div 3770$ = power density in mw/cm^2

$H^2 \times 37.7$ = power density in mw/cm^2.

The following table shows the full-scale readings of each range in terms of effective power density.

PROBE	RANGE	FULL SCALE VALUE |FSU|^2	V/M	"Eff Pwr Density" mw/cm^2
GREEN	1	10^2 V^2/M^2	10	2.65×10^{-2}
GREEN	2	10^3 "	30	2.65×10^{-1}
GREEN	3	10^4 "	100	2.65
RED	4	10^5 "	300	26.5
RED	5	10^6 "	1000	265
RED	6	10^7 "	3000	2653
H	A	.1 A^2/M^2	N/A	3.77
H	B (w/Attenuator)	1.0 A^2/M^2	N/A	37.7
HSE-01	A	N/A	1	2.65×10^{-3}
HSE-01	B	N/A	3	2.65×10^{-4}

2.5 EXPOSURE STANDARDS

The table below shows the standards for human exposure to electromagnetic energy of frequencies from 300 KHz to 100 GHz. These guides are part of the American National Standards Institute (ANSI) C95.1 standard released in October, 1982.

RADIO FREQUENCY PROTECTION GUIDES

(1) Frequency Range (MHz)	(2) Power Density (mw/cm^2)	(3) E^2 (V^2/M^2)	(4) H^2 (A^2/M^2)
0.3 - 3	100	400,000	2.5
3 - 30	$900/f^2$	4,000 ($900/f^2$)	0.025 ($900/f^2$)
30 - 300	1.0	4,000	0.025
300 - 1500	f/300	4/000 (f/300)	0.025 (f/300)
1500 - 100,000	5.0	20,000	0.125

Note: f is the frequency, in Megahertz (MHz)

For both pulsed and non-pulsed fields, the power density and the squares of the field strengths, as applicable, are averaged over any 0.1 hour period and should not exceed the values given above.

Section 3
MAINTENANCE

3.1 INTRODUCTION

This section contains instructions for routine maintenance and minor fault isolation.

3.2 BATTERY STATUS

If the battery status LED is glowing steady, the batteries must be replaced or recharged (see below).

3.3 REPLACING BATTERIES

A. Standard Battery Pack

The standard battery pack consists of 14 alkaline C cells. The battery holder is fastened to the bottom of the inner instrumentation housing. Unsnap the four latches holding the outer instrumentation housing and remove it. Holding the meter upside down, slide off the retaining strap and remove old batteries. Replace batteries, observing polarity as shown in the bottom of the battery holder. Slide retainer back into place. Replace outer instrumentation housing taking care not to pinch wires or battery clips.

B. Rechargeable Ni-cad Option

The ni-cad battery pack is also composed of 14 C-size batteries. It can be recharged by plugging in the charger which is supplied with the option. The charger operates on either 115 or 220 VAC, 50/60 Hz. To change the operating voltage of the charger you must first remove the four screws holding it together. Lift the front panel off and turn it over. The slide switch controls the operating voltage of the charger. Push it toward the transformer for 115 volt operation, or away from the transformer for 220 volt operation. Ni-cad batteries should be

fully discharged before being charged. Recharging time is 7 hours. The charger should not be left plugged in for longer than 24 hours. The instrument is not operable with the charger plugged in.

The ni-cad battery pack is in the bottom of the outer instrumentation housing. If it becomes necessary to replace the ni-cad pack unsnap the four latches holding the outer instrumentation case and remove it. Lift out the ni-cad pack, disconnect the two leads coming from it. One lead has an in-line connector and the other an in-line fuse holder. Insert new battery pack and reconnect both connectors. Replace meter, being careful not to pinch wires.

3.4 UNIT COMPLETELY DEAD

If the battery status LED does not light or blink when the selector switch is turned on, the battery voltage is too low, or the fuse is open. Refer to 3.3 to open the unit for access to the fuse. If the fuse is good, the batteries should be replaced or recharged. If the fuse is open, check for pinched, shorted wires, or defective connections. Replace fuse (3 AG, ½ amp, slow blow); if fuse blows again, unit should be returned to factory for repair.

CAUTION: The latches which hold the outer instrumentation case can exert considerable force. Make certain the case is properly fitted to the front panel before securing latches, or the front panel will become deformed. In addition to the mechanical damage, the effectivity of the RFI seal is lost.

3.5 RECALIBRATION

It is recommended that this instrument be recalibrated annually. If you do not have access to a suitable calibration facility, you may return the instrument to our factory for recalibration at a nominal fee.

Section 4

SYSTEM DESCRIPTION

4.1 INTRODUCTION

The HI-3001 is a portable, rugged, easy-to-use instrument with a wide dynamic range. It employs an internal digital memory to capture the highest reading observed for display when desired on the unit's analog meter. It also has automatic full-time zeroing of the meter to eliminate the effects of offset, noise, pickup and drift while measurements are being made.

4.2 INSTRUMENTATION OVERVIEW

The front panel controls of the HI-3001 are relatively simple. (See figure 1) Most prominent is the range selector switch. There are six ranges for E-field readings and two auxiliary ranges. The six ranges are selected by one of three positions of the rotary range selector switch and one of two probes.

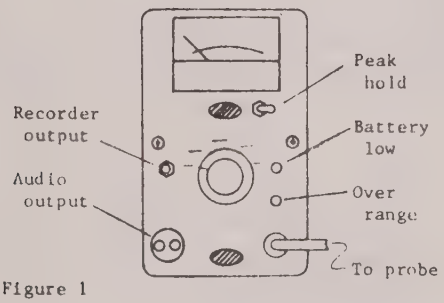


Figure 1

The analog meter displays the reading in volts squared per meter squared (V^2/M^2). The analog signal is also available at the recorder output jack, which is calibrated for one volt output for full-scale meter deflection. The output is also converted to an audio signal, which is a ticking sound, proportional to meter deflection. LED indicators show over range conditions and battery status. The momentary switch labeled peak hold is used to recall the highest reading from the memory.

4.3 PROBE OVERVIEW

The HI-3001 is supplied with two E-field probes. The green probe covers the range from 10 to 10^4 V^2/M^2 and the red probe covers the range from 10^4 to 10^7 V^2/M^2. The probes are comprised of three mutually orthogonal diode dipoles based on the design originated at NBS, Boulder, Colorado. (See figure 2)

Figure 2

4.4 ELECTRONICS PACKAGE

The electronics package consists of three boards; the front panel board, the digital board and the analog board. (See figure 3)

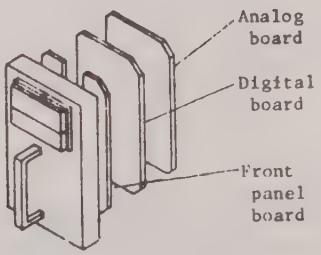


Figure 3

Contained on the front panel board are three switching power supplies, the meter driver, a battery low indicator driver and sense circuits, audio and recorder output driver circuits. The digital board contains the necessary circuitry which sums the three orthogonal channels and also contains the stored curve reconstruction circuit necessary to reconstruct the impinging

field present at the antenna. The analog board contains the necessary multiplexing and scaling circuits required to condition the signal for conversion to a digital word by the A to D, which is also contained on the analog board.

The entire unit is powered by a single voltage battery pack consisting of 14 alkaline batteries. An optional rechargeable ni-cad battery pack is also available.

4.5 SIGNAL FLOW

The operation of the HI-3001 can best be understood by following a signal through the meter.

The equivalent circuit of the antenna system can be seen in Figure 4. It should be noted that the antenna and diode assembly is simply a short dipole terminated by a diode detector. The 0.4 PFD capacitance is the capacitance equivalent of the short dipole antenna. The diode in this case is modeled as an ideal diode. The 100,000 ohm resistance represents that section of the high resistance feed system that occurs before any distributed capacitance is associated with the feed system. The 6 PFD capacitance represents a lumped element model of the distributed capacitance of the high resistance feed line. The 1 meghohm resistance is the series resistance of the high resistance line and the 60 PFD capacitance is the capacitance found in the multiple conductor shielded line. The 10 megohm is the input impedance of the differential amplifier. The entire feed system therefore looks like a peak detector followed by a low pass filter. The rolloff of this low pass filter is approximately 400 Hz.

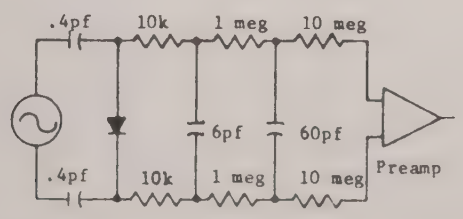


Figure 4

The feed system is connected to the preamplifier. The pre-amplifiers are differential input and are matched and zeroed. (See figure 5) The preamps drive a multiplexer which takes the individual channels and assigns a time slice to them. (See figure 6)

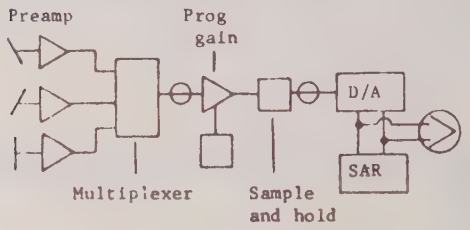


Figure 5

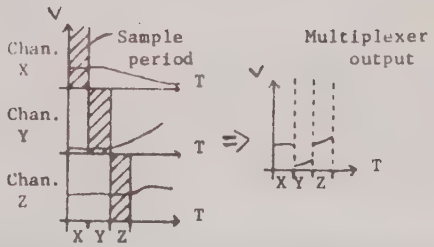


Figure 6

The sampling rate for this multiplexer is approximately 30 KHz giving each preamplifier a sample rate of approximately 8 KHz. The multiplexer then feeds a programmable gain section. The gain is selected via mosfet switches controlled by the front panel rotary switch. Figure 6 is a graph representing the time sliced input signal X, Y and Z. The programmable gain stage then drives a sample and hold. The sample and hold merely samples the incoming signal at a prescribed time and holds it for the duration until the next sample is updated. (See figure 7) The sample and hold feeds the analog to digital convertor. The analog to digital convertor is comprised of a D to A convertor and a successive approximation register (SAR). The output of the analog to digital convertor, represented as X, Y and Z, now drives the digital board. (See figure 8)

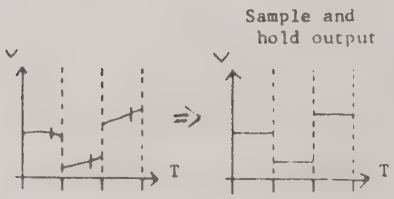


Figure 7

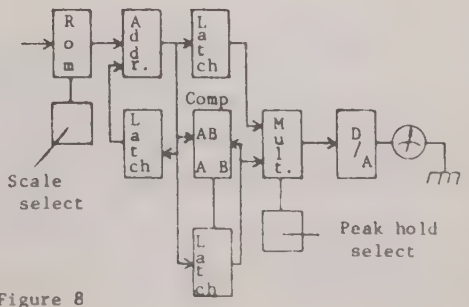


Figure 8

The data coming from the analog board forms a digital word whose value is proportional to the probe output voltage. This, when applied to the address of the ROM, defines a unique location in the ROM, due to the monotonic nature of the diode transfer curve. The ROM itself contains numbers which represent the field strength necessary to generate that diode output level. Therefore, the ROM yields a true representation of the field strength of each of the three orthogonal components X, Y and Z. It should be noted that in order for the ROM to accomodate a 100% modulated signal the ROM has to be extended to 400% of the full scale value. These field strengths then go into an adder section. The adder is comprised of an adder and a latch, comprising a bite wide serial adder. Figure 9 is representative of the sequence in which the additions occur. Upon sampling Channel X the latch is initially cleared. X is then converted by the ROM and applied to the A input of the adder. Since the output latch is initially cleared and is applied to B input the sum port of the adder contains only X.

Time slice	Rom input	Rom output	Adder output	Adder latch	Sum latch
1	X	X*	X*	-0-	$(X+Y+Z)^{T-1}$
2	Y	Y*	X*+Y*	X*	"
3	Z	Z*	X*+Y*+Z*	X*+Y*	"
4	-	0	0	0	$(X+Y+Z)^{T}$
5	X	X*	X*	0	"
6	Y	Y*	X*+Y*	X*	"

* Value after SCR

Figure 9

This stored is the latch. Y is now applied to input A and the output of the latch, which contains X, is applied to the B input. Therefore, the sum contains X plus Y. This is continued one more iteration so that the sum of the adder contains X plus Y plus Z. At this point, since the ROM contained the field strength in each of the three coordinates as defined by the diode output, the sum of the adder contains

a number representing the space power density. This number is then latched in an output latch found directly to the right of the adder. The two boxes directly below the output latch labeled comparitor and peak hold latch comprise the peak hold function. The output of the adder is applied to the A input of the comparitor and the latch labeled peak hold latch is applied to the B input of the comparitor. When the incoming signal on A is greater than the signal on B, A > B output will go high thus latching the new incoming signal. Therefore the latch contains the word which is representative of the maximum signal received by the meter. The multiplexer found to the right of these latches simply selects the current output latch or the peak hold latch. The multiplexer drives a digital to analog convertor which converts the digital word back into an analog signal for driving the meter movement and the recorder output. It should be noted, however, that the peak hold function captures only the modulation envelope that is passed by the transmission line. Since the transmission line has a rolloff of 400 Hz, the peak hold will see a modulation envelope as filtered by a single pole 400 Hz lowpass filter. The analog meter on the other hand has rolloff characteristic of approximately 1 Hz. Therefore it is possible that the actual modulation envelope may be higher than the analog meter deflection.

4.6 AUTOMATIC ZERO

This feature eliminates the need for a zero adjustment and eliminates temperature drift problems associated with previously available instrumentation. The automatic full time zero also allows the operator to use the meter immediately upon turning it on.

The operation of the automatic zeroing can be seen in Figure 10.

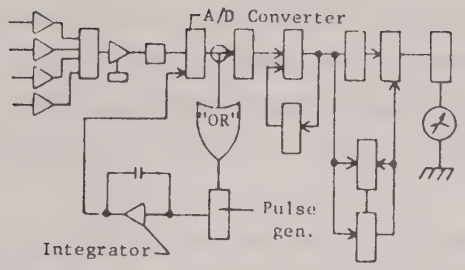


Figure 10

Included in the meter is a 4th channel called the Redundant Channel. This channel is identical to the other three channels except that instead of being driven by a dipole-diode element it is terminated in the probe head by a carbon resistor simulating the zero bias impedance of the Schottky Barrier Diode in series with the high resistance feed line. It is also subjected to the same temperature variations as the high resistance feed lines of the other three channels. The redundant channel feeds a preamp which is matched to the other three preamps. It is then fed into the same multiplexer and analog gain path as the other three channels. Therefore any drifts associated with the programmed gain stage, sample and hold stage and multiplexer are also contained in the 4th redundant channel with the absence of signals due to the diode-dipole-antenna system. The 4th channel is allocated a time slice and is presented to the analog to digital conversion. The output of the analog to digital convertor is a digital word which represents only the amount of signal which is due to common mode pickup and drifts of the different gain stages. This word should ideally be equal to zero with any word other than zero representing an unwanted noise or drift. If a value other than zero occurs an integrator is charged up which subracts this offset. Thus a closed loop has been generated which subtracts analog zero shifts and gain shifts from the remaining three channels. It can be seen that the only circuits prone to zero shifts are the analog circuits. The digital circuits following do not drift.

The drifts associated with the final digital to analog convertor are insignificant compared to the signal levels present. Therefore the entire meter is protected against zero drifts and temperature variations.

It can be seen that an autozeroing techique of this nature yields a zeroing signal that oscillates about true zero at 1/2 the sample rate of the instrument. Step sizes correspond to the amount of charge the integrator acquires during one correction interval and the slope at which the integrator can charge determines the maximum slope the automatic zeroing circuit can follow. (See figure 11) This rate of change is many times faster than the temperature and zero drifts, making the zero very stable and accurate during use. When the instrument is first turned on, however, or when changing scales, large offsets may be introduced which may take approximately a second or more for the auto zero circuit to correct.

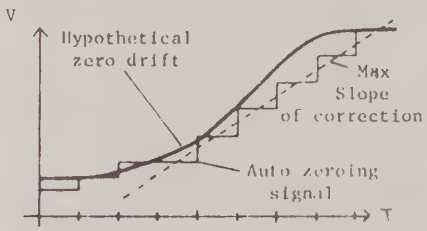


Figure 11

4.7 ERRORS

Errors associated with the HI-3001 are generated primarily by two sources. The first source is the instrumentation electronics itself. The second source is associated with the limitations of the sensing probe.

Those errors caused by the instrumentation electronics section of the HI-3001 are primarily due to nonlinearities in the analog to digital and the digital to analog convertors, the look up ROM and analog meter movement itself. The total error of the electronics package is about three percent.

Errors associated with the limitations of the probe fall into three categories; those of the frequency response of the antenna, modulation response errors and multiple frequency detection errors. The response of the meter as specified is ±1 dB from 1 MHz to 1 GHz and ±2 dB from .5 MHz to 6 GHz. The response outside this band does exhibit a reasonably sharp rolloff. The high end response drops rapidly above 6 GHz due to the selective loading of the dipole and the diode package characteristics. This is true for all probes whose serial numbers have a GR suffix. Early model probes without loading show a response peak at about 3.3 GHz of as much as +12 dB. The low frequency rolloff is predominantly controlled by the shunt capacity of the diode and the stray capacity associated with the initial section of the high resistance feed lines. Below about 3 MHz it is very difficult to manufacture feed lines that are transparent enough so that they do not act as an unwanted antenna. The equivalent impedance of the very short dipole antenna becomes extremely high at the low frequency region and even with the extremely high impedance of the Schottky Barrier Diode without bias a good match insuring effective energy transfer from the desired antenna to the detection element is nearly impossible. Below 0.6 MHz any electrical unbalance of the feed lines or capacitive coupling to electrodes supporting the electric field being measured can cause false readings. It is important that the user of any instrument having high input impedances associated with the detection system such as the HI-3001 be aware of the general spectrum of the fields being measured. A prime example of this would be to attempt to measure the low frequency electromagnetic radiation of a CRT with the HI-3001. A CRT generates a substantial field at about 15 KHz with a decaying spectrum to about 100 KHz. These signals can induce voltages into the detection system via the feed lines rather than the antennas and hence it is impossible to correlate the reading of the instrument to a meaningful calibration. The same may be said about the case where measurements are attempted in the presence of extremely high 60 Hz fields such as would be found under very high voltage power lines.

NOT GOOD FOR 7 GHz STL & ICR

A second form of error occurs in the form of modulation error. As was noted earlier the detected signals are fed to the instrumentation package by means of high resistance lines. These lines and the associated distributed capacitance form a low-pass filter between the detection element and the signal shaping circuit. Because the associated circuits following the detection diode can not follow the instantaneous signal the input to the lookup table will be different from the ideal and corresponding output will in general be lower for the peaks and higher for the valleys. This will result in slight errors for low levels of modulation below 400 Hz and significant errors for 100 percent modulation at higher modulation frequencies. Table 1 shows the comparison of 100 percent sinusoidal modulation to a pure cw case.

Table 1: Modulation Errors

Modulation Freq. (Hz)	Meter Error (DB)
20	+0.61
50	+0.51
100	+0.51
200	+0.31
500	0.00
1000	-0.11
2000	-0.22
5000	0.00
10000	+0.61

Note: All modulations are 100% sinusoid

It should be noted that the HI-3001 and the HI-3002 meters were designed specifically to measure electric and magnetic fields associated with industrial and communication uses as opposed to the low duty short pulse modulation of microwave radar systems. what about FM broad

The third form of error associated with the antenna-detector system occurs when two or more nearly equal strength signals, whose frequencies are in the detection band of the instrument, are imposed on the antenna. This error occurs because the signals are summed by the detection element which is not, except for relatively low level signals, a square law detector.

Instead, the diode along with its R-C circuit acts very much as a peak detector relying on the lookup ROM to restore square law characteristics over most of the upper dynamic range of the instrument. The typical transfer characteristic of the family of diodes used in the 3000 series instruments is shown in Figure 12.

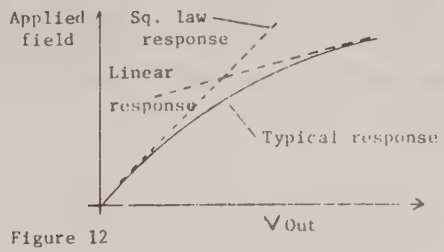


Figure 12

The instrument will therefore read higher than true. This is shown by a simple example as follows. We will assume that there are two electric fields impinging on the probe. Let the amplitudes of these fields be A1 and A2 accordingly. It can be seen that the effective power density is proportional to A1 squared plus A2 squared. (That is the sum of the squares of the fields at the point of reception, Equation 1A.) If we assume that diode detector elements of the probe are operating in the purely linear region of the diode's curve and the squaring is done after the two signals are summed it can be seen that Equation 1B represents the formulation of the effective power density. Equation 1C compares Equations 1A and 1B and it

$$A1^2 + A2^2 \quad (1A)$$

$$(A1 + A2)^2 = A1^2 + 2A1A2 + A2^2 \quad (1B)$$

$$\frac{(A1^2 + 2A1A2 + A2^2) - (A1^2 + A2^2)}{A1^2 + A2^2} = \frac{2A1A2}{A1^2 + A2^2} \quad (1C)$$

can be seen that $2A1A2/A1^2 + A2^2$ is the error term. This error term approaches 1 as A1=2A. Therefore, with the probe exposed to two equal signals falling in the nondispersive region of the frequency response curve of the antenna, and if the diode is acting as a peak detector in the ideally linear region of the diode curve, the instrument would theoretically yield a +3 dB error. In a careful evaluation using a TEM cell, Ric Tell of EPA, Las Vegas has measured this effect for the case of two and three equal electric fields. These results are compared to the idealized worse case using the assumptions previously discussed. (See table 2)

Table 2: Multiple Frequency Errors

Meter Reading $(V/M)^2$	Ideal Reading $(V/M)^2$	Meter Error (DB)
48	40	+0.79
460	400	+0.61
6000	4000	+1.76

Note: F_1 = 1 MHz, F_2 = 100 MHz, both of equal amplitude.

It can be seen that the experimental results are far less severe than that predicted by the simplistic worse case calculations. This is explained for the most part by the fact that the diode does in fact operate over most of its characteristic curve which does approximate square law at the low field levels and never reaches the pure linear region. It should be noted that in a practical sense one would rarely find nearly equal multiple frequency fields in health and safety measurements and any resulting error would be positive in nature. This would prevent errors of the type which might underestimate field strengths. Again, if the user does observe measurement levels approaching recommended exposure, care must be taken to consider the spectrum of the fields being measured.

Section 5
SPECIFICATIONS

5.1 SYSTEM CHARACTERISTICS

A. Full-time automatic zero! Even while performing measurements.
B. Peak hold memory circuit.
C. LED indicators for overload and battery status.
D. Audio output, ticking sound is proportional to meter reading.
E. Recorder output, 0 to 1 volt corresponding to meter reading.
F. Instrumentation readout is in field strength units squared or V/M (see section 5.4).
G. Operates on 14 C size batteries.
H. Size (instrumentation package): 8 1/8" x 5 1/8" x 4 7/8".
I. Weight: 6.5 lbs.
J. Total length of probe and handle with probe inserted: 30 inches.
K. Overload: Can withstand CW signal to 800% of full scale of maximum probe range.

5.2 PROBE SPECIFICATIONS, STANDARD PROBES

	Green Probe	Red Probe
Range 1	$10^2 V^2/M^2$ Full Scale	$10^5 V^2/M^2$ Full Scale
Range 2	$10^3 V^2/M^2$ Full Scale	$10^6 V^2/M^2$ Full Scale
Range 3	$10^4 V^2/M^2$ Full Scale	$10^7 V^2/M^2$ Full Scale

Frequency Response: 0.5 MHz to 6 GHz : ±2 dB
1 MHz to 1 GHz : ±1 dB
3 MHz to 500 MHz : ±.5 dB

Isotropicity: ±.5 dB for both Green and Red probes

Calibration accuracy at calibration frequencies: ±.5 dB for both probes.

5.3 PROBE SPECIFICATIONS, OPTIONAL PROBES

Model Number Type of Field	STH-01 H-field	HSE-01 E-field
Aux A	.1 A^2/M^2 Full Scale	1.0 V^2/M^2 Full Scale
Aux B (with adapter)	1.0 A^2/M^2 Full Scale	10 V^2/M^2 Full Scale
Frequency Response (±2 dB)	5 MHz to 300 MHz	.5 MHz to 3 GHz
Isotropicity	± .5 dB	Aux A: ± 1 dB Aux B: ± .5 dB
Calibration accuracy at calibration frequencies	± .5 dB for both probes	

5.4 OPTIONAL READOUT

If your instrument is identified as HI-3001A the readout units are V/M. Probe range values are:

	Green Probe	Red Probe
Range 1	10 V/M Full Scale	300 V/M Full Scale
Range 2	30 V/M Full Scale	1000 V/M Full Scale
Range 3	100 V/M Full Scale	3000 V/M Full Scale

	HSE-01
Aux A	1.0 V/M Full Scale
Aux B	3.0 V/M Full Scale

All other probe specifications remain the same. The STH-01 is not available on the HI-3001A.

Section 6
WARRANTY SERVICE

6.1 LIMITED WARRANTY

Holaday Industries, Inc. warrants each Model HI-3001 Isotropic Broadband Field Strength Meter to be free from defects in material and workmanship under normal use and service for a period of 90 days from date of shipment. This warranty extends to the original purchaser only. This warranty does not apply to fuses, batteries, or any products or parts that have been subject to misuse, neglect, accident, or abnormal conditions of operation.

In the event of instrument failure covered by this warranty, Holaday Industries, Inc. will repair and recalibrate the instrument if returned to their factory within 90 days of the original purchase, provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within the warranty period, said repairs or replacement will be made without charge. If the defect was caused by misuse, neglect, accident, or abnormal conditions of operation, repairs will be billed at a nominal cost. In such a case, an estimate will be submitted before work is started, if requested.

6.2 INSTRUCTIONS IN CASE OF DEFECT

A. Notify Holaday Industries, Inc. giving full details of the difficulty, and include the serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

B. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the factory and the instrument returned to you, transportation prepaid.

6.3 CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon delivery to the purchaser. All material should be checked against the enclosed packing list. Holaday Industries, Inc. cannot be responsible for shortages against the packing list unless a claim is filed with the carrier immediately. To obtain a quotation to repair shipping damage, contact Holaday Industries, Inc. Final claim and negotiations with the carrier must be completed by the customer.

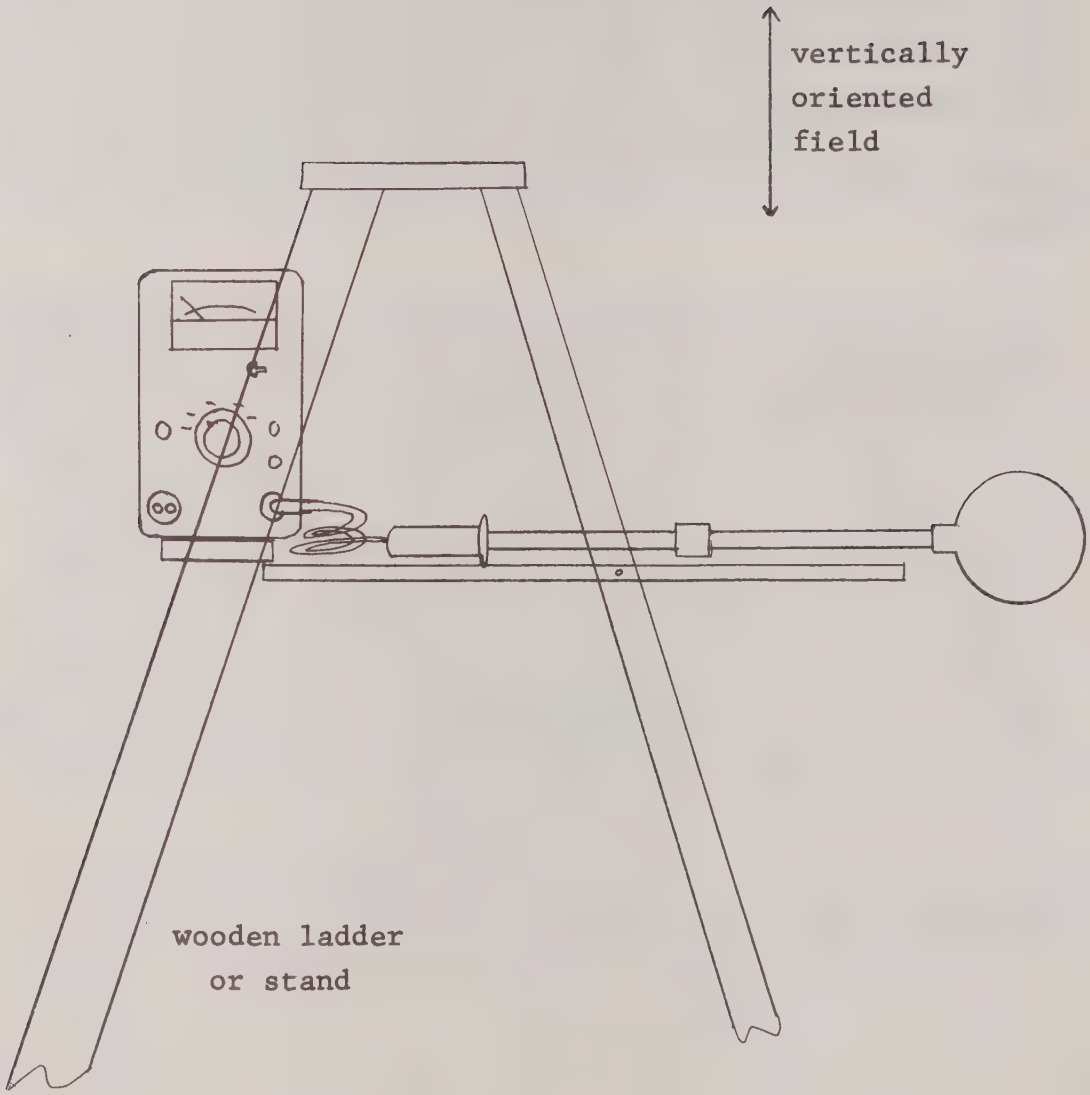
Section 7
TECHNICAL NOTES

7.1 LOW FREQUENCY MEASUREMENTS

This bulletin identifies procedures to be followed to maximize the accuracy of measurements near the low frequency end of the instrument response band. Even though the feed lines from the probe are as transparent to RF as possible, they may act as an unwanted antenna, especially at frequencies below approximately 3 MHz.

When making measurements of this frequency, such as around AM broadcast towers, it is possible to minimize unwanted pickup by placing the probe handle perpendicular to the field orientation and carefully coiling the probe cord in the same plane as the probe handle. Also, the probe should be kept well away from the body or any object which could cause reflections or re-radiation to be picked up by the probe. This scattering or reflection can cause falsely high readings. It is recommended that the instrument be placed on a non-conducting support, such as a wooden stepladder or stand. Back away from the instrument until the reading stabilizes. The meter scale is easily read from several feet away.

See sketch on the next page for one suggested method of measurement near an AM broadcast tower.


vertically
oriented
field
wooden ladder
or stand

7.2 VDT Measurements

DO NOT use any HI-3000 series broadband meter to measure non-ionizing radiation around video display terminals, television sets or any CRT. Any significant field strength produced by these devices can be characterized as having most of its energy spectrum well below the usable frequency range of the HI-3000 instrument. These fields may cause a reading on the instrument due to the fact that the probe will respond to some of the higher order harmonics. However, this reading cannot be related to a meaningful, calibrated field strength level.

cc: Holaday
HI-3001
equip file

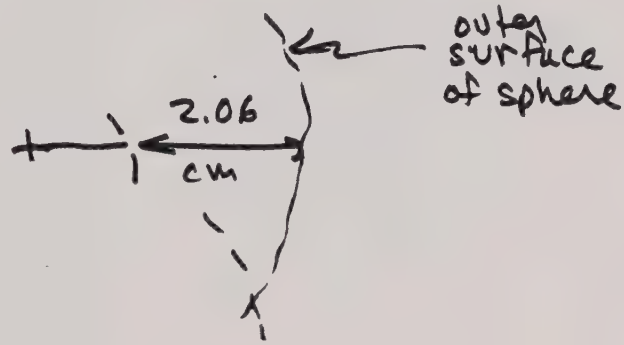
GE150
880803

telcon to Burton Kram
Holaday
(612) 934 4920

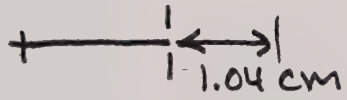
10cm = 3.94"

distances from outermost active probe element to surface of ~~10.1~~ 10.0 cm diam Styrofoam sphere

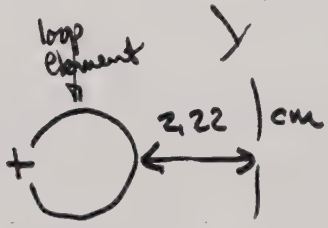
RED
E field
(high level)



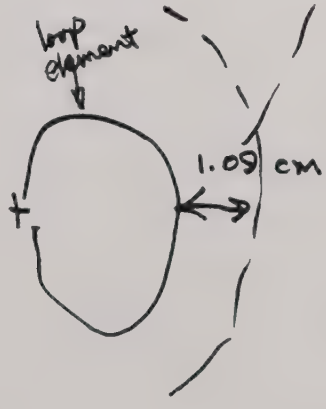
GREEN
E field
(low level)



YELLOW
H FIELD
(VHF Mag probe)



BLACK
H FIELD
(Low Freq
Mag probe)



-Yellow Probe Sensitivity-
Full Scale Readings
For the CH Probe Are: AUX.A = 0.1 A^2/M^2
AUX.B(with adapter) = 1.0 A^2/M^2

-Black Probe Sensitivity-
Full Scale Readings
For the LFH (Low Frequency H field) Probe Are:
AUX.A = 1.0 A^2/M^2
AUX.B(with adapter) = 10 A^2/M^2

Cal
May 1988

- Designed for 30 dB attenuation at microwave frequencies.
- Protection at VHF/UHF broadcast frequencies approximately 10 to 20 dB.
- Material is a hybrid of stainless steel and fire-retardant DuPont Nomex III fibers.
- Acceptance by FCC, EPA, OSHA, & other agencies not established.
- About $600

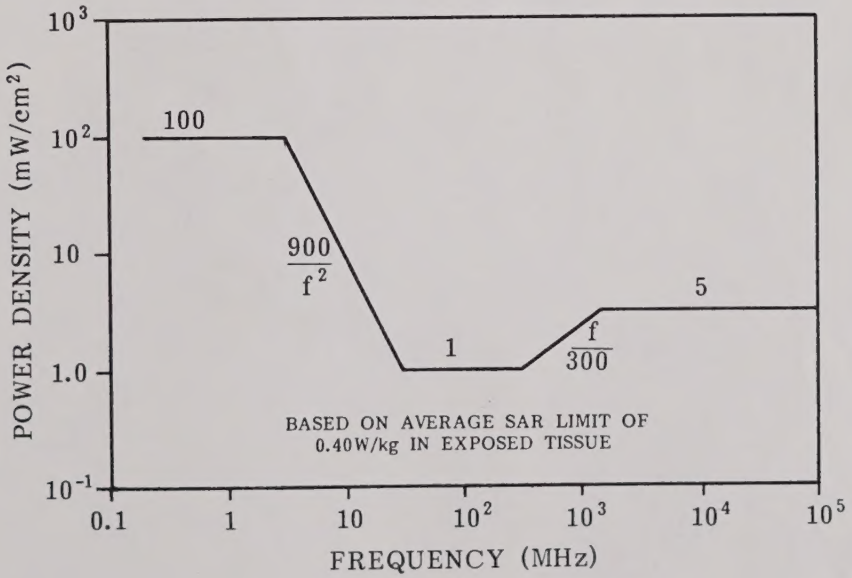
		PROTECTIVE CLOTHING LION APPAREL "M GUARD" SUIT
HAMMETT & EDISON, INC. CONSULTING ENGINEERS SAN FRANCISCO	NATIONAL ASSOCIATION OF BROADCASTERS	870910

AMERICAN NATIONAL STANDARD SAFETY LEVELS WITH RESPECT TO HUMAN EXPOSURE TO RADIO FREQUENCY ELECTROMAGNETIC FIELDS, 300 KHZ TO 100 GHZ

RADIO FREQUENCY PROTECTION GUIDES

Frequency Range (MHz)	E^2 (V^2/m^2)	H^2 (A^2/m^2)	Power Density (mW/cm^2)
0.3 - 3	400 000 (632 v/m)	2.5	100
3 - 30	4 000 ($900/f^2$)	0.025 ($900/f^2$)	$900/f^2$
30 - 300	4 000	0.025	1.0
300 - 1500	4 000 (f/300)	0.025 (f/300)	f/300
1500 - 100 000	20 000	0.125	5.0

Note: f = frequency (MHz).



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CONSULTING ENGINEERS
SAN FRANCISCO

SUMMARY OF
ANSI C95.1-1982 STANDARD